Electric Propulsion for Deep-Space Missions

Abstract for the 3rd International Symposium on Space Propulsion

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The use of ion propulsion for deep-space missions will finally become a reality with the launch of NASA's New Millennium DS1 spacecraft in 1998. This event will take place approximately 38 years after the first broad-beam, electron-bombardment ion engine was successfully operated in the laboratory and will instantly create an new standard against which advanced propulsion technologies must be measured. No longer will it be sufficient for a proposed new propulsion technology to claim better performance relative to chemical systems. Now, for new propulsion technologies to be adopted they must show significant performance advantages relative to the DS1 ion propulsion system. While many aspects of this system were intentionally conservative, it has considerable performance capability which is not easily surpassed. Fortunately there are many interesting destinations in the solar system which are very difficult to get to from a propulsion standpoint and the performance of the DS1 ion propulsion system can be shown to be inadequate to accomplish these missions. This creates the need for the development of advanced electric propulsion technologies. The goals of these advanced propulsion technologies are to: enable new missions, reduce total mission costs, and reduce mission flight times. This paper discusses the results of a study looking at the relative merits of advanced electric propulsion technologies for ambitious deep-space missions. The advanced electric propulsion systems considered include derivatives of the DS1 system to extend the power range and total impulse capability. A ¼-scale DS1 system derivative for application to smaller planetary spacecraft, a direct-drive system based on a high specific impulse version of the thruster with anode layer (TAL).